WHAT IS CLAIMED IS:

1. A Fabry-Perot (FP) laser apparatus mode-locked to a multi-frequency lasing light source as a light source for Wavelength Division Multiplexing WDM-based optical communications, comprising:

an optical amplifier that amplifies inputted optical signals;

a laser light source that wavelength division demultiplexes a first part of the inputted optical signals, multiplexes the demultiplexed optical signals, re-transmits the multiplexed optical signals, wavelength division demultiplexes the remaining part of the amplified optical signals, and outputs signals mode-locked to the demultiplexed signals; and

a first circulator that inputs the remaining part of the amplified optical signals into the laser light source, and outputs, to an optical transmission link, optical signals mode-locked to the multi-frequency lasing light source outputted from the laser light source.

2. The FP laser apparatus of claim 1, wherein the laser light source comprises:

a wavelength division multiplexing/demultiplexing device, having one multiplexing port and N-1 demultiplexing ports arranged in each of a first and second side of the device, that wavelength division demultiplexes the optical signals inputted into the multiplexing port and outputs the demultiplexed signals, and wavelength division multiplexes the optical signals inputted into the N-1 demultiplexing ports and outputs the multiplexed signals;

N-1 reflection mirrors, connected to the second-side demultiplexing ports of the wavelength division multiplexing/demultiplexing device, that reflect the demultiplexed signals and re-input the demultiplexed signals into the second-side demultiplexing ports of the wavelength division multiplexing/demultiplexing device; and

N-1 FP lasers, connected to the first-side demultiplexing ports of the wavelength division multiplexing/demultiplexing device, that output the signals mode-locked to the demultiplexed signals.

3. The FP laser apparatus of claim 1, wherein the optical amplifier comprises:

a first and second amplifying fiber that amplify the inputted optical signals using stimulated emission of a rare earth element;

a pumping light source that outputs pumping light of a predetermined wavelength for pumping the first and second amplifying fiber;

a second splitter that partially splits the pumping light, couples the partially split pumping light to the first amplifying fiber, and couples the remaining pumping light to the second amplifying fiber; and

a second circulator having a first, second and third port that receive the optical signals amplified by the first amplifying fiber from the first port and outputs the amplified optical signals to the laser light source connected to the second port, and receives the wavelength division multiplexed signals, outputted from the laser light source, from the second port and outputs the multiplexed signals to the second amplifying fiber connected to

the third port.

4. The FP laser apparatus of claim 3, wherein the optical amplifier further comprises a first bandpass filter, arranged between the third port of the second circulator and the second amplifying fiber, having the same bandwidth as the output wavelength division multiplexed optical signals, wherein, signals outside of the bandwidth are removed.

5. The FP laser apparatus of claim 3, wherein the rare earth element is erbium.

6. The FP laser apparatus of claim 2, wherein the wavelength division multiplexing/demultiplexing device is an NxN waveguide grating router.

7. The FP laser apparatus of claim 2, further comprising:

N-1 polarization controllers connected between the N-1 FP lasers and the wavelength division multiplexing/demultiplexing device; and

a polarizer connected to the first circulator and the first splitter.

8. An optical transmission apparatus for transmitting upstream and downstream signals of a PON (Passive Optical Network) in which a central office, a remote node and a plurality of subscriber devices are connected through a transmission optical fiber, comprising:

the central office comprising -

a light source having FP lasers outputting signals for transmission that are mode-locked to multi-frequency lasing light and directly modulated based on downstream data,

a circulator connected to the light source that downstream-transmits the signals mode-locked to the multi-frequency lasing light and directly modulated, and outputs optical signals for upstream-transmission from the remote node to the transmission optical fiber,

a plurality of upstream optical receivers that receive the upstream-transmitted optical signals,

a plurality of first wavelength division multiplexers/demultiplexers that multiplex/demultiplex input/output signals of the FP lasers and upstream channels for input into the upstream optical receivers,

a pumping light source that outputs pumping light of a predetermined wavelength to drive the upstream multi-frequency lasing light source, and

a second and third wavelength division multiplexers/demultiplexers that multiplexes/demultiplexes the upstream/downstream-transmitted signals and a

pumping signal;

the remote node comprising -

a multi-frequency lasing light source having an NxN waveguide grating router that demultiplexes the multiplexed downstream signals for transmission and the multi-frequency lasing light and multiplexes optical signals transmitted from the subscriber devices, and

a fourth and fifth wavelength division multiplexer/demultiplexer that multiplexes/demultiplexes the upstream/downstream-transmitted signals and the pumping signal; and

the subscriber devices each comprising -

an FP laser that receives the optical signals transmitted from the remote node and outputs for transmission directly modulated mode-locked signals based on upstream data,

a downstream optical receiver that receives downstream channel signals demultiplexed and transmitted by the remote node, and

a sixth wavelength division multiplexer/demultiplexer that multiplexes/demultiplexes input/output signals of the FP laser and downstream channels for input into the downstream optical receiver.

9. The optical transmission apparatus of claim 8, wherein the light source having the FP lasers outputting signals mode-locked to multi-frequency lasing light and directly modulated, comprises:

an optical amplifier that amplifies inputted optical signals;

a laser light source that wavelength division demultiplexes a part of the inputted optical signals, multiplexes the demultiplexed optical signals, re-transmits the multiplexed optical signals, wavelength division demultiplexes a remaining part of the amplified optical signals, and outputs signals mode-locked to the demultiplexed signals; and

a first circulator that inputs the remaining part of the amplified optical signals into the laser light source, and outputs, to an optical transmission link, optical signals mode-locked to the multi-frequency lasing light source outputted from the laser light source.

10. The optical transmission apparatus of claim 8, wherein the light source arranged in the central office and the multi-frequency lasing light source arranged in the remote node comprise a first and second bandpass filter having different wavelength passbands such that wavelength bands of the upstream and downstream signals are different.

11. The optical transmission apparatus of claim 10, wherein the first and second bandpass filter have the same passband as one free spectral range of the waveguide grating router, and center wavelengths of the first and second bandpass filters are separated by at least one free spectral range.

12. The optical transmission apparatus of claim 1 0, wherein the second a nd fifth wavelength division multiplexer/demultiplexer are configured to pass signals of a passband of the first bandpass filter and a passband of the second bandpass filter.

13. The optical transmission apparatus of 10, wherein the third and fourth wavelength division multiplexer/demultiplexer are configured to pass signals of a passband of the first bandpass filter and a passband of the second bandpass filter and the pumping signal from the central office.

14. The optical transmission apparatus of claim 8, further comprising a plurality of polarization controllers and a polarizer installed in the central office and between the remote node and the subscriber devices,

wherein the efficiency of a mode lock of the FP lasers is improved.

15. A Passive Optical Network (PON) based on Wavelength Division (WDM) multiplexing comprising:

a central office having a Fabry-Perot (FP) laser apparatus according to claim 2 as a light source;

a remote node having a Fabry-Perot (FP) laser apparatus according to claim 2 configured as a multi-frequency lasing light source and connected to the central office through a transmission optical fiber; and

a plurality of subscriber devices that are connected through a transmission optical fiber to the remote node.

16. The PON of claim 15, further comprising a plurality of polarization controllers and a polarizer installed in the central office and between the remote node and the subscriber devices, wherein the efficiency of a mode lock of the FP lasers is improved.

17. The PON of claim 15, wherein the light source arranged in the central office and the multi-frequency lasing light source arranged in the remote node further comprise a first and second bandpass filter having different wavelength passbands such that wavelength bands of an upstream and a downstream signal are different.